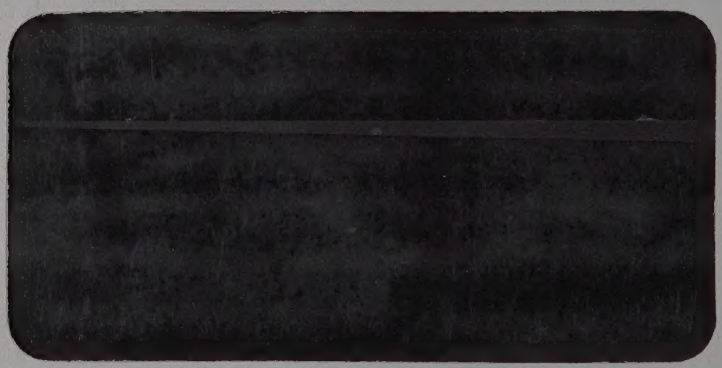
C. 1

BIDDLE
INSTRUMENTS

BM 11

Instruction Manual

The Measure of Excellence
in Electrical Testing



BM 11

SERVICE INFORMATION

BM11 Battery MEGGER Tester

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Part No 6171-071 Edition 1/2Q

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1. INTRODUCTION

1.1 The Instrument

The BM11 is a 5000 V portable,high voltage, high sensitivity insulation tester. It is operated from internal rechargeable cells and is used for heavy duty insulation testing of motors, generators, transformers, power cables etc.

Any difference found between this information and the instrument under repair may be due to small design changes which constantly affect such instruments.

1.2 Safety

1.2.1 Safety in the use of Electrical Equipment

It should be understood that any use of electricity involves some degree of safety hazard.

Whilst every effort is made by responsible manufacturers to reduce the hazard, it still rests with the user to play his part in ensuring his own safety.

The best way to achieve this is:-

Understand the equipment you are proposing to use and its ratings.

Understand the application to which the equipment is to be put.

Ensure that all reasonable safety procedures are followed.

Take no chances, nor short cuts, in safety procedures.

1.2.2 Safety precaution

The BM11 uses triplicate current limit circuitry to ensure that it cannot produce a lethal electric shock (even under fault conditions) and its thick plastic case protects the operator from dangerous voltages within. However, the instrument should be treated with respect and the following guidelines are worth knowing:

(1) Don't lock the push button down unless it is absolutely necessary.

(2) Don't demonstrate the effectiveness of the current limit by touching the terminals when the instrument is operating. (It is remotely possible that all current limiters are faulty).

WARNING

If the BM11 is removed from its case the current limits become ineffective and the bare chassis should be regarded as highly dangerous. It can be rendered safe by either:

(a) Switching to battery check position, or

(b) Removing the two battery fuses.

It is a wise precaution to do both before making any adjustments or repairs.

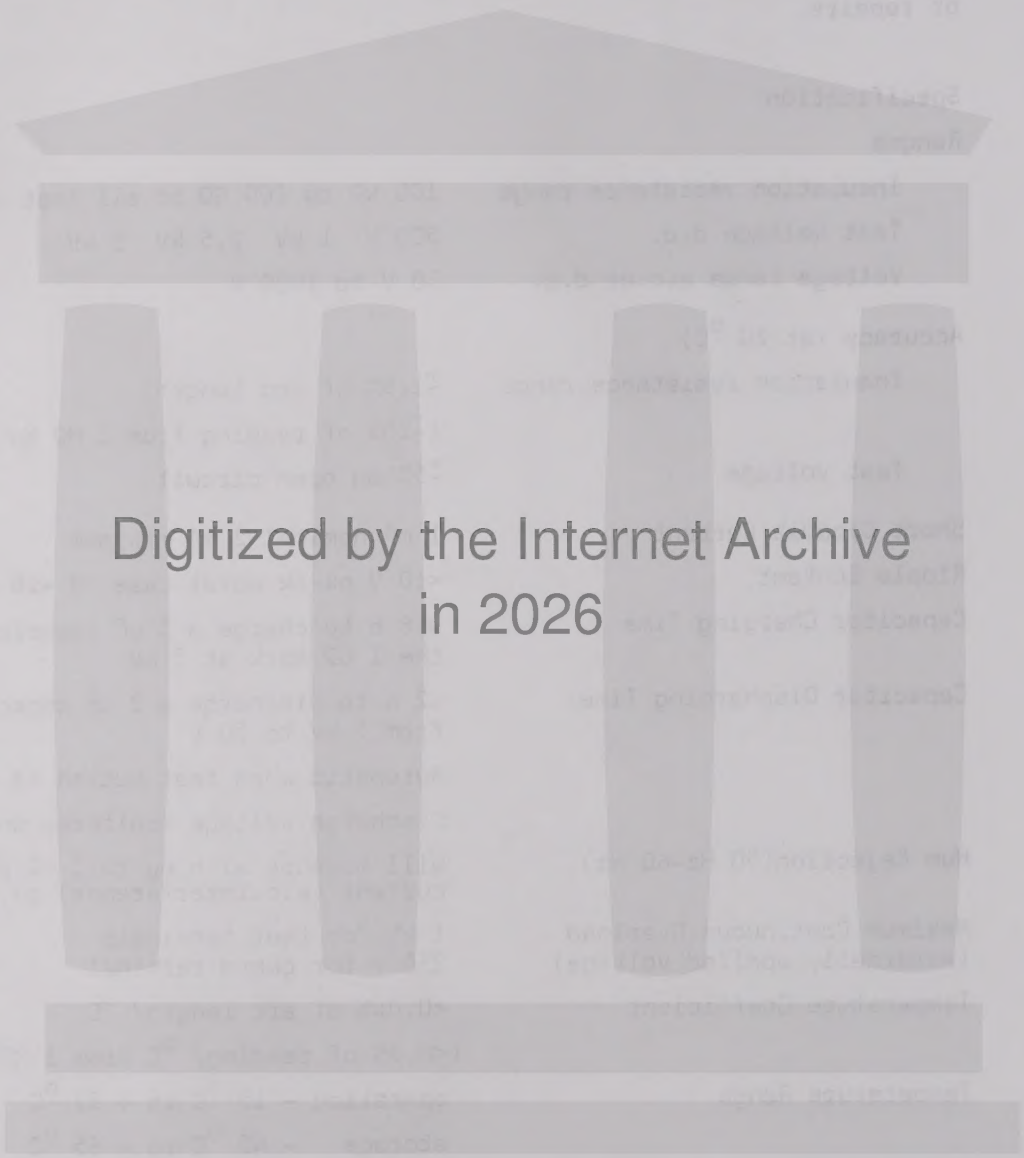
1.3 Specification

Ranges

Insulation resistance range	100 kΩ to 100 GΩ at all test voltages
Test voltage d.c.	500 V 1 kV 2,5 kV 5 kV
Voltage range a.c.or d.c.	50 V to 1000 V

Accuracy (at 20 °C)

Insulation resistance range	±1,5% of arc length (±20% of reading from 1 MΩ to 10 GΩ)
Test voltage	±5% on open circuit
Short Circuit Current	1 mA nominal 2 mA maximum
Ripple Content	<10 V pk-pk worst case (R <10 MΩ)
Capacitor Charging Time	<18 s to charge a 2 µF capacitor to the 1 GΩ mark at 5 kV
Capacitor Discharging Time	<2 s to discharge a 2 µF capacitor from 5 kV to 50 V Automatic when test button is released Discharge voltage monitored on the meter
Hum Rejection(50 Hz-60 Hz)	Will measure with up to 2 mA r.m.s. hum current (a.c.interference) on 5 kV range
Maximum Continuous Overload (externally applied voltage)	1 kV for test terminals 250 V for guard terminal
Temperature Coefficient	<0,04% of arc length/ °C (<0,5% of reading/ °C from 1 MΩ to 10 GΩ)
Temperature Range	operating - 15 °C to + 55 °C storage - 40 °C to + 65 °C
Scale Length	123 mm
Power Supply	NiCd battery pack of 2 Ah capacity Battery life:-typically 8 h continuous varying between 2 h and 20 h depending upon load conditions)



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Battery charging:-built-in charging unit, operating from 100 V - 250 V a.c. supply, 50 Hz or 60 Hz

Charging time:-16 h

Low battery voltage indication:-small oscillations of the pointer occur with an approx. 80% exhausted battery. Large pointer oscillations occur when battery must be recharged.

Dimensions	344 x 245 x 158 mm
	(13½ x 9⅝ x 6¼ in)
Weight	4,8 kg (10½ lb) excluding leads

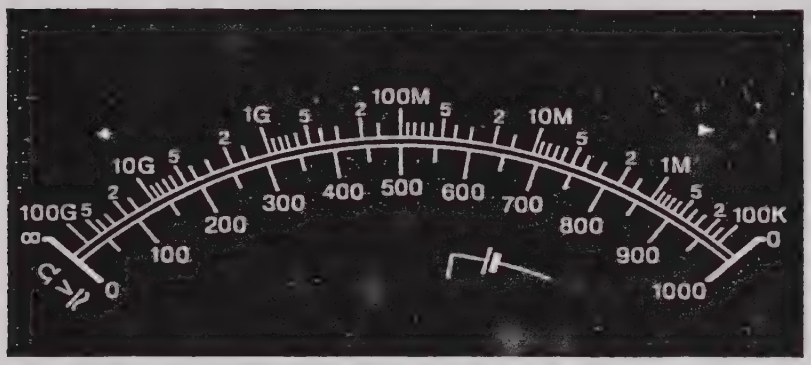
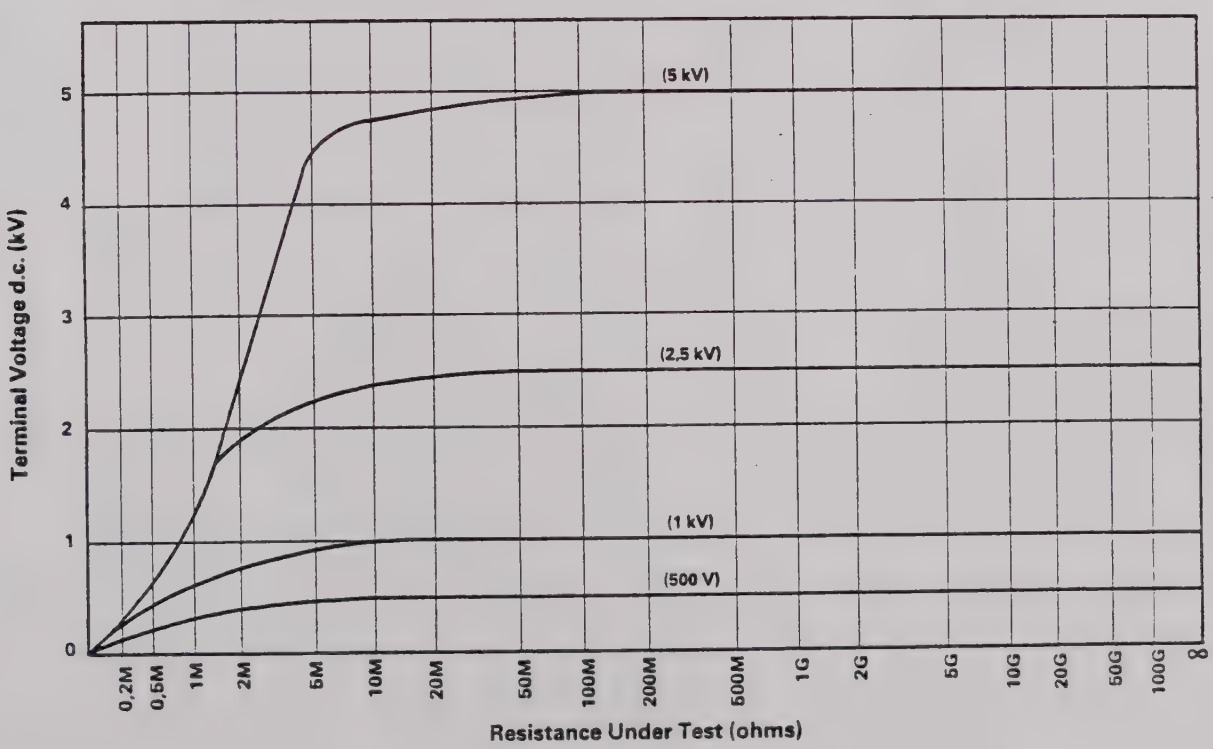


Illustration of BM11 scale (not full size)



Typical terminal voltage characteristics

1.4 Accessories

Supplied with the instrument

High voltage test leads 3 m long with clips (three)	Part No 6331-248
Battery charging mains supply lead	Part No 25424-860
Operating instruction book	

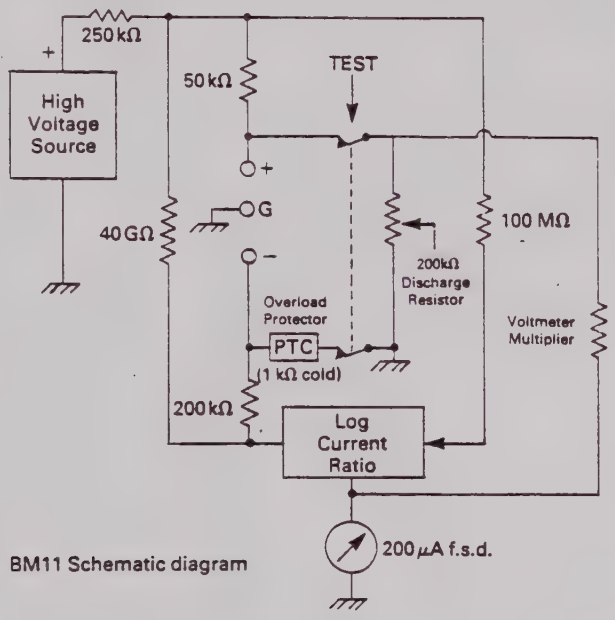
Supplied at extra cost

High voltage leads 8 m long with clips	Part No 6331-249
Leather case for test leads (clips to lid of instrument)	Part No 6430-193

2. CIRCUIT DESCRIPTION

(see also the block diagram of the complete circuit and the circuit diagram)

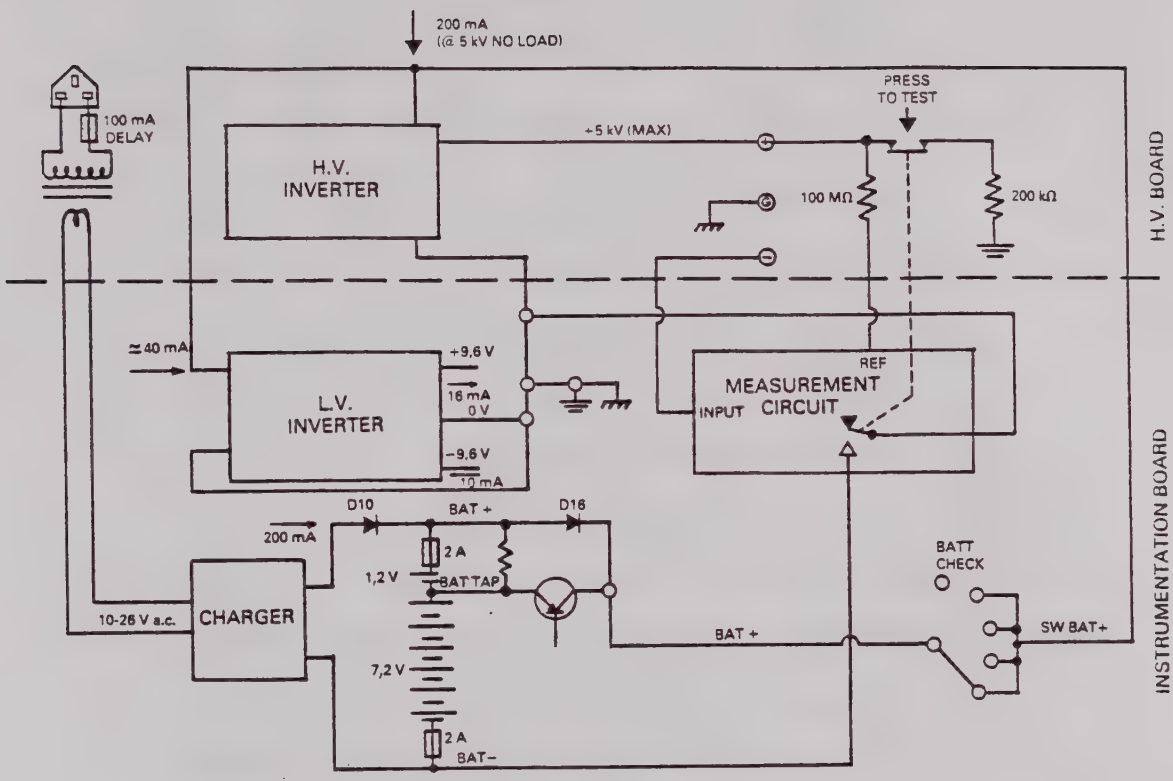
There are two main sections within the tester, the inverter, producing the high test voltage, and the current measuring circuit. The high voltage '+' terminal is positive with respect to the guard 'G' and '-' (measurement) terminals.



BM11 Schematic diagram

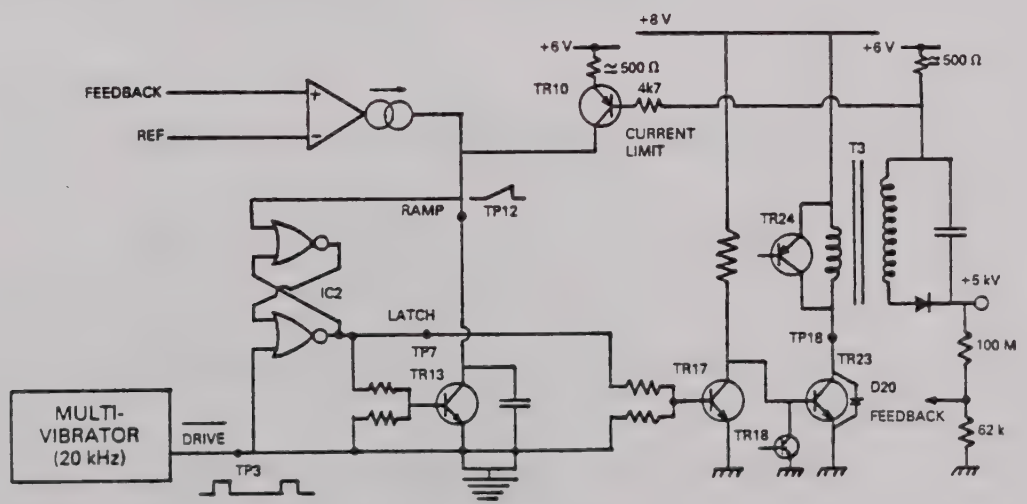
The maximum allowable continuous voltage that may be applied to the test terminals is:-

The maximum current through all terminals is 2 mA.



Block diagram of complete circuit

2.1. The Inverter



Simplified diagram of h.v. inverter

The inverter operates in three modes:

(i) Constant output voltage for low loads, i.e. resistances >10 MΩ.

(ii) Constant output power for heavy duty loads, i.e. resistance approx. 5 MΩ.

(iii) Constant output current for very heavy loads and short circuit.

A multivibrator runs at approximately 20 kHz and generates the master timing signal $\overline{\text{DRIVE}}$.

The circuit operates then as follows (refer to the waveforms below)

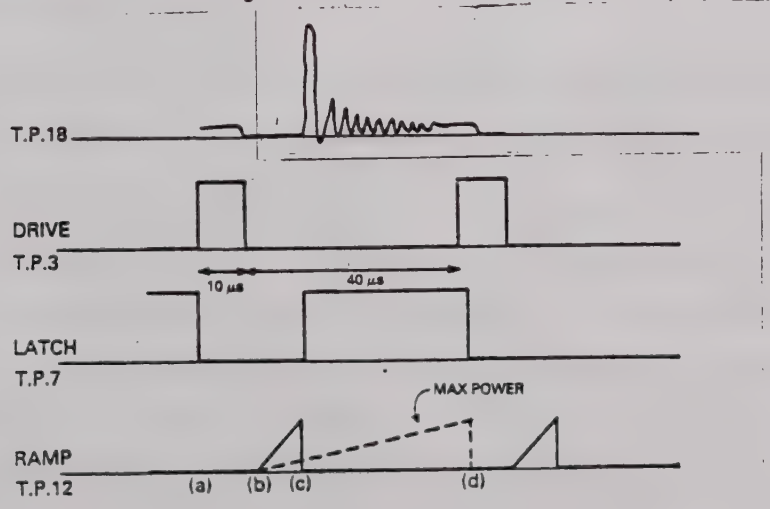
(a) When $\overline{\text{DRIVE}}$ goes high it sets LATCH low. There is a 10 µs rest period.

(b) When $\overline{\text{DRIVE}}$ goes low TR13 and TR17 are turned off, RAMP starts to rise and transformer primary current starts to rise.

(c) When RAMP reaches a threshold level LATCH is reset, RAMP returns to zero and the current in the transformer primary is turned off. TR18 ensures that the transformer drive circuit is not turned on again until all the energy in the transformer has been dumped onto the secondary capacitors.When dumping is complete the transformer tends to oscillate. Excessive negative voltage excursions on TR23 collector are prevented by the diode D20.(See design modification page 36)

(d) Any remaining oscillation is damped when TR24 turns on 10 µs prior to the start of the next charging cycle.

Maximum power available is 3,5 W with battery at 6 V and more than 3,5 W at higher battery voltages. An output voltage of 5 kV can therefore be maintained on load resistances down to 7 MΩ. (Note that there is always a 500 kΩ resistance in series with the output and this will cause a 5% drop in the available voltage to a 10 MΩ load).



Typical waveforms at 5kV on light load

2.1.1 Current Limit

(see simplified diagram of H.V. inverter plus circuit diagram)

The maximum current available is limited to approximately 1 mA by TR10. This value of current limit is not only a safety feature but also reduces battery consumption considerably under short circuit conditions.

In the event of failure of TR10 or any of its associated components TR15 will limit current to about 1,5 mA by turning on TR17 and preventing any drive to the transformer. Under these conditions the instrument will operate normally but the transformer will screech. Some fault conditions (e.g. R40 going short circuit) can prevent both transistors TR10 and TR15 from operating. This type of fault is detected by TR12 which will turn the inverter off completely.

In the event of multiple fault conditions which cause both these current limits to fail then the maximum current is determined by the amount of power which can be supplied to the 300 kΩ series resistor. With a battery of less than 8 V (7,2 V is nominal) this current will be less than 6 mA.

To check operation, short circuit the test terminals with a milliammeter of f.s.d. = 10 mA. Operate on 5 kV range. Short circuit current should be $\simeq$ 1,2 mA $\pm$ 20% Link pins TP8 and TP9, this should produce approx. 1,5 mA and the transformer will probably screech. Remove link. Link TP11 and TP15. This should produce 0 mA.

To disable the current limit circuit disconnect resistors R32 and R43. The maximum current available will now be approx. 5 mA.

2.2 The Current Measuring Circuit

(refer to the circuit diagram)

The measurement circuit uses a pair of matched transistors to produce a voltage proportional to the logarithm of the ratio of leakage current (current through test sample) to applied voltage. The scale shape is of the basic form $\frac{1}{5} \log_{10} \frac{100}{R}$ where R is the resistance of the test sample in MΩ. Deliberate cramping at each end of the scale enables the 0 and ∞ marks to be shown and still give five decades of resistance measurement.

The matched pair of transistors TR27 and TR28 operate in conjunction with op-amp IC3 to produce a voltage on the base of transistor TR28 which is proportional to the logarithm of the ratio of the current through the test terminals to the current through the 100 MΩ reference

resistor (R94). The second amplifier IC5 has a gain of about 21,2 at 20 °C and has a temperature coefficient of about -0,33% per °C which compensates for the temperature coefficient of the transistors. Potentiometer B (R80) allows a correction factor to be introduced to compensate for TR27 emitter resistance. For the majority of transistors this correction is not necessary and potentiometer B is set fully anti-clockwise. Potentiometers D (R119) and F (R113) are linearity controls. TR32 acts as a zener diode (approx. 7 V) in series with a diode and protects the meter movement from excessive currents.

The fault detector ensures that the instrument still works in voltmeter mode if SW1a fails to make. Under normal conditions when the 'TEST' button has been released and voltage is still present at the terminals voltage will appear on FDOF and TR30 will disable the fault detector. If voltage is present at the terminals but SW1a fails to make then current flows through FDET, TR29 and TR31 and through the meter movement, thus giving an approximate voltage reading.

The input filter (C25, C26, C28, C29) will accept hum currents at levels up to 2 mA r.m.s. for frequencies of 50 Hz, 60 Hz or their harmonics without causing errors.

In the off state capacitor C29 is kept charged to battery voltage. When the instrument is switched on this capacitor applies its charge to the measured circuit via the filter. This causes a distinct deflection of the pointer towards mid-scale irrespective of what is connected to the terminals. This gives the user confidence that the instrument is operating - even if the terminals are connected to an open circuit - and also ensures that the logarithmic amplifier starts off in a correctly biassed state.

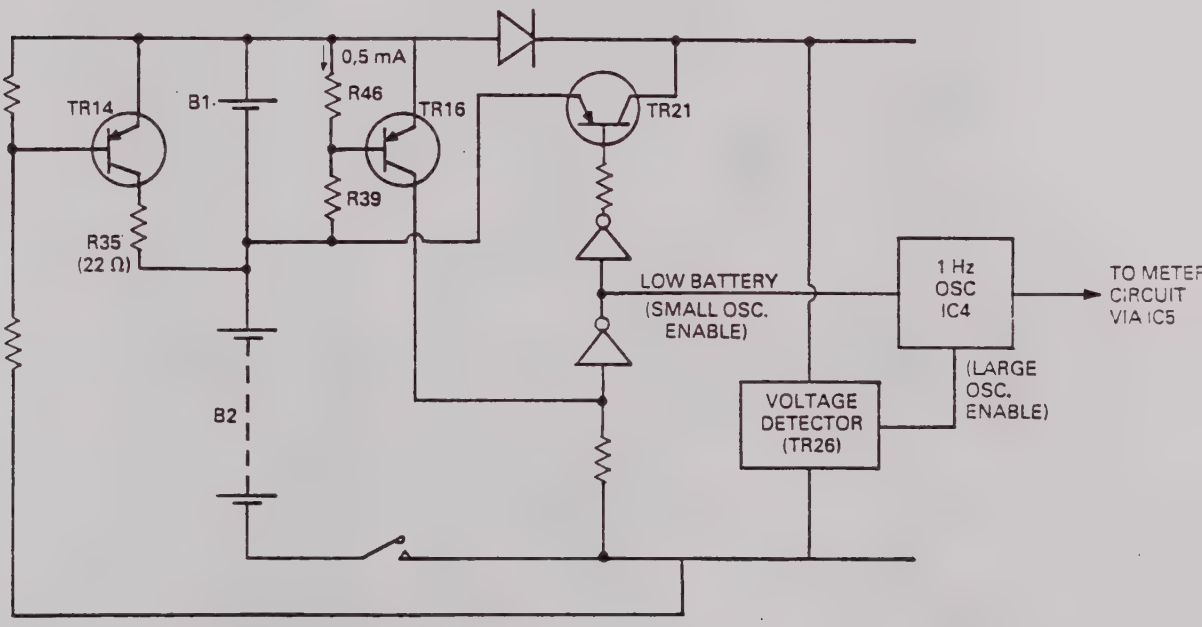
2.3 Low Battery Detector

Current is only drawn from the battery while the 'TEST' push-button is pressed. The battery life is typically 8 hours if the instrument is used at 5 kV test voltage, with varying resistive loads with parallel capacitance between 0 and 2 µF. However, the instrument can supply 4,75 kV to a 10 MΩ load and if used in such a condition continuously will exhaust the battery in 2½ hours.

Note:- under short circuit conditions the 1 mA current limit comes into operation and the battery drain is then quite low.

A battery check facility is provided on the rotary switch. This checks the battery voltage with a dummy load when the test button is pressed. However, checking nickel cadmium cells in this way is of very limited value as their voltage gives no indication of their state of charge other than showing if they are completely exhausted.

To give the user an indication when the battery is approaching an exhausted state the following low battery detection system is used:- The battery consists of seven nickel cadmium cells in series. One of the cells (B1 in the diagram below) is deliberately drained at a higher rate than the remainder (B2). A small current is drained continuously through R39 and R46. When the 'TEST' button is pressed a larger current (approx.50 mA) drains B1 through R35. This ensures that B1 will become exhausted before B2 (typically leaving B2 with about 20% of its total charge).



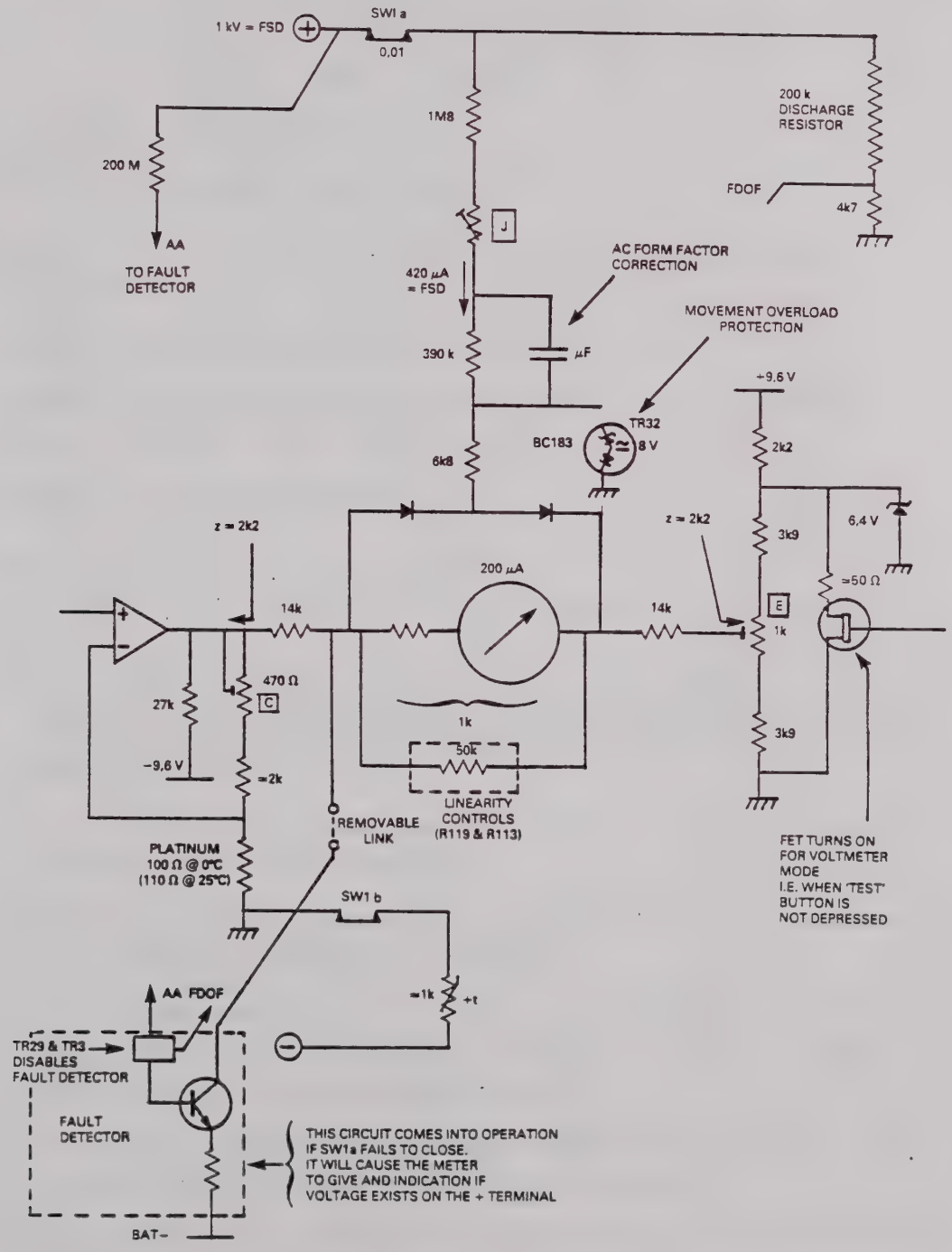
Simplified diagram of low battery detector circuit

When this condition is reached, the voltage of B1 is detected by TR16. This turns on transistor TR21 and also activates the oscillator which causes visible oscillations on the meter pointer.

If B2 becomes exhausted so that there is insufficient voltage to operate the instrument the voltage detector circuit causes large oscillations to be superimposed on the pointer thus preventing a measurement from being made. A l.v. cut off circuit is incorporated to prevent the instrument giving a bad reading when there is insufficient battery voltage to operate the "low battery" oscillations. TR5 cuts the power

off when the battery voltage falls below 3 V and latches off until the voltage rises above 4,3 V.

2.4 Voltmeter Circuit



Simplified voltmeter circuit diagram

3. DISMANTLING

WARNING: If the BM11 is removed from its case the current limits become ineffective and the bare chassis should be regarded as highly dangerous. It can be rendered safe by either:
a) Switching to battery check position, or
b) Removing the two battery fuses.
It is a wise precaution to do both before making any adjustments or repairs.

CAUTION: see paragraph 3.5

3.1 Removing the Instrument from the Case

1. Switch to the battery check position.
2. Remove the instrument lid by folding it back as far as possible and continuing the pressure.
3. Turn the instrument upside down and remove the four feet.
4. Beneath the feet are four cross-head screws, remove the screws and lift the case clear of the instrument.
5. Remove the two battery fuses.

3.2 Removing the Two Printed Circuit Boards

The two p.c.b's can be removed as a single assembly in the following way:

1. Remove the BAT - (black), BAT TAP (yellow), BAT + (red), L (brown), N (blue), and E (green) connections. All these are located by the battery fuse holders.
2. Remove the two meter connections, M+ or M1 (red) and M- or M2 (black), located below the main terminals.
3. Remove the -ve terminal connection (identified by its PTFE sleeve and located between the batteries and meter.
4. Disconnect the coupler on the shaft of the rotary switch. (Check that the switch is in the battery check position before so doing in order that it may be refitted correctly).
5. If the p.c.b. chassis is to be removed completely the red high voltage wire should be unsoldered from the tag on the board.
6. Using an 8 mm spanner slacken the six pillars which fasten the boards to the front panel. Remove the pillars by continuing to unscrew them with

a 2 pt cross-head screwdriver applied to the screw in the pillar end.

7. Lift the p.c.b. chassis away from the front panel.

3.3 Separation of the Two Printed Circuit Boards

1. Remove both springs from the push-button high voltage switch.
2. Lift the metal lever away from the board thus allowing the shaft to be rotated and withdrawn from the lower board.
3. Disconnect the eleven wires between the boards.
4. Remove the two nuts from two of the pillars and lift off the measurement board.

3.4 Reassembly Hints

1. Check the tightness of the push-on connectors which could have been loosened during disassembly.
2. Position the meter movement wires before screwing up the p.c.b. chassis.
3. Rotate the switch to fully anticlockwise to set it in the battery check position.

3.5 Caution:- The instrument circuit contains static sensitive devices. If the instrument casing is opened for any reason, care must be exercised in handling the printed circuit board. This should be done in accordance with DEF STAN 59-98 and BS 5783, specifications for handling electrostatic sensitive devices.

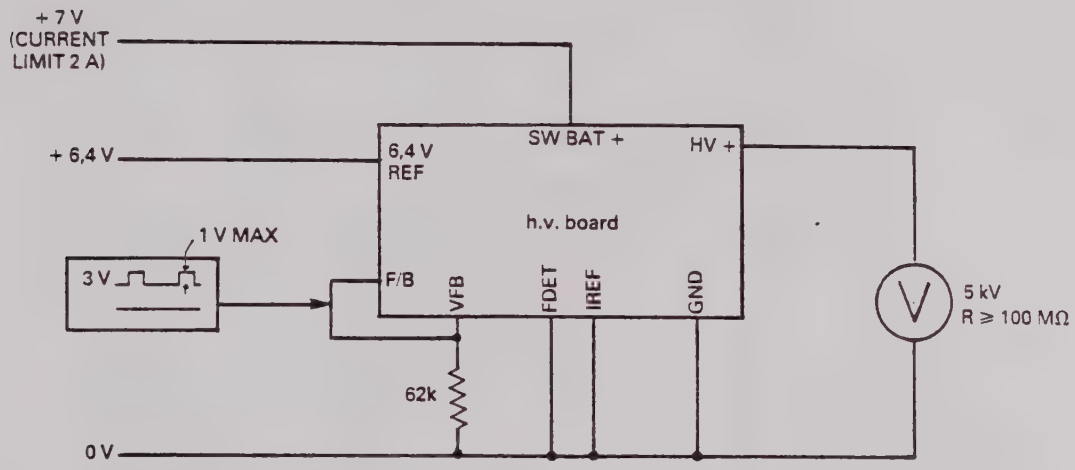
Printed circuit boards containing such devices are identified either by a yellow warning label or, by a yellow legend and a large yellow dot on the p.c.b. (Initially the dot may not be included).
Early instruments will not have this yellow indication.

4. CIRCUIT TESTS AND CHECKS

(refer to the circuit diagram and p.c.b. layout diagram)

4.1 High Voltage Board, (tested in isolation from the instrument).

WARNING - This board generates high voltages at dangerously high power levels.



Circuit to test h.v. board

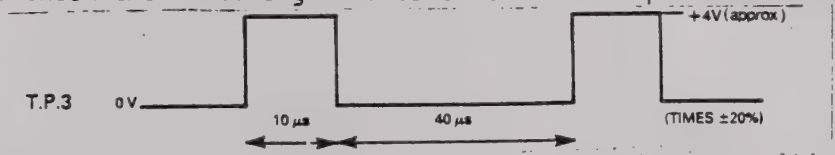
Work through these basic steps to test the circuit.

1. Visual check:

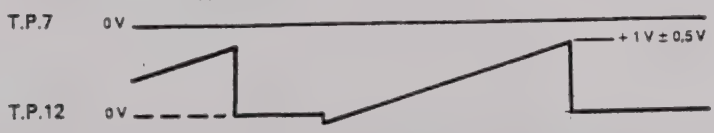
   Polarities of 3 x 100 µF Electrolytic capacitors C22, C23,C24
   1 x 2,2 µF Tantalum capacitor C46
   14 x Diodes and Zeners D5, D6, D8, D14, D15, D18, D19, D20, D23, D29, D38, D39, D40, D41.

2. Connect TP16 to GND (TP21) to disable the high voltage generator. Current consumption <30 mA under this condition.

3. Check the following waveforms at the test points mentioned.

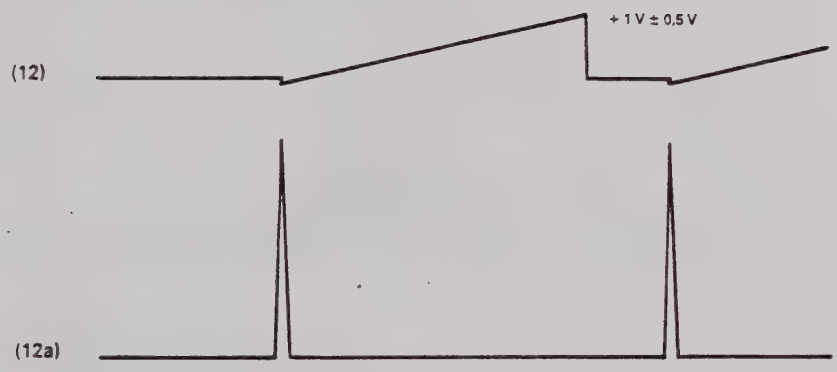


if not fault is possibly in the +5 V supply, the multivibration TR1/TR4 etc. or IC2.



if not fault is in IC1 circuitry, TR2/TR3, TR10 or TR13

Temporarily connect F/B to 6, 4 V REF and observe the change in waveform at TP12 (see waveforms below at 12 and 12a).



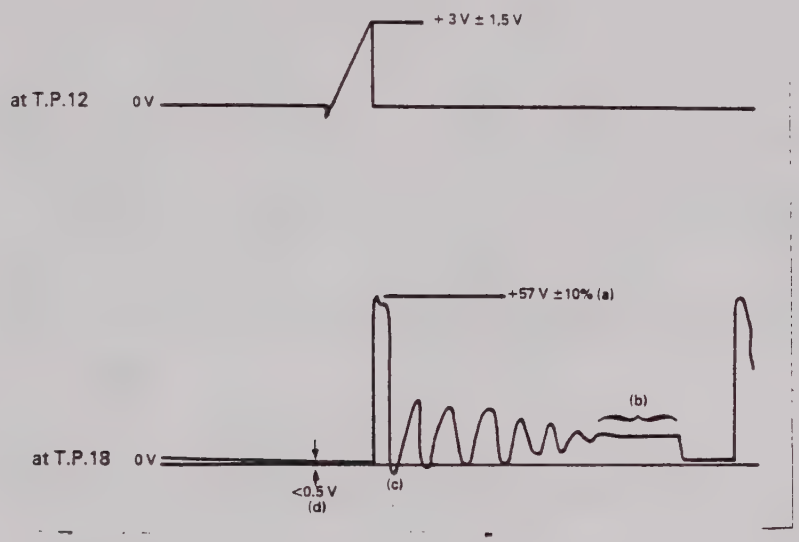
If either of the waveforms 12 or 12a are not obtained there is a fault in the control circuit in the region of IC1, TR2 and TR3 or alternatively IC2 or TR13 may be at fault.

(Useful servicing hint:- A tempory short circuit may be fitted across the two circular brass contacts of SW1a. This will prevent excessive voltages being generated even if there is a fault in the control circuit).

4. Remove link (TP16 to TP21) to activate the high voltage.
5. Set voltage to 5 kV using pot K. (R2)

   if this cannot be achieved check connections to T3.
6. Check current consumption <250 mA

   if not check R52 D18 D20 TR24.
7. Check waveform



   if waveform is not as above

   (a) check diodes D23 to D29, or T3 wiring.

   (b) clamp period affected by TR24/TR25.

   (c) negative excursion should not exceed 3 V - check D20.

   (d) fault lies in TR20/TR23. (See design modification page 36).

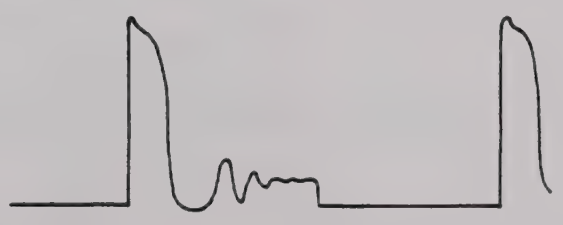
8. Connect a 10 mA meter between H.V. output and ground and check short circuit currents.

Condition	Current	if not Fault Location
Normal	1 mA - 1,5 mA	TR10
Link TP8 to TP9	1 mA - 2 mA (transformer will screech)	TR15
Link TP11 to TP15	0 (±0,1) mA	TR12

9. Load with 10 MΩ and check voltage droop to be less than 200 V.

   Also check current consumption <750 mA.

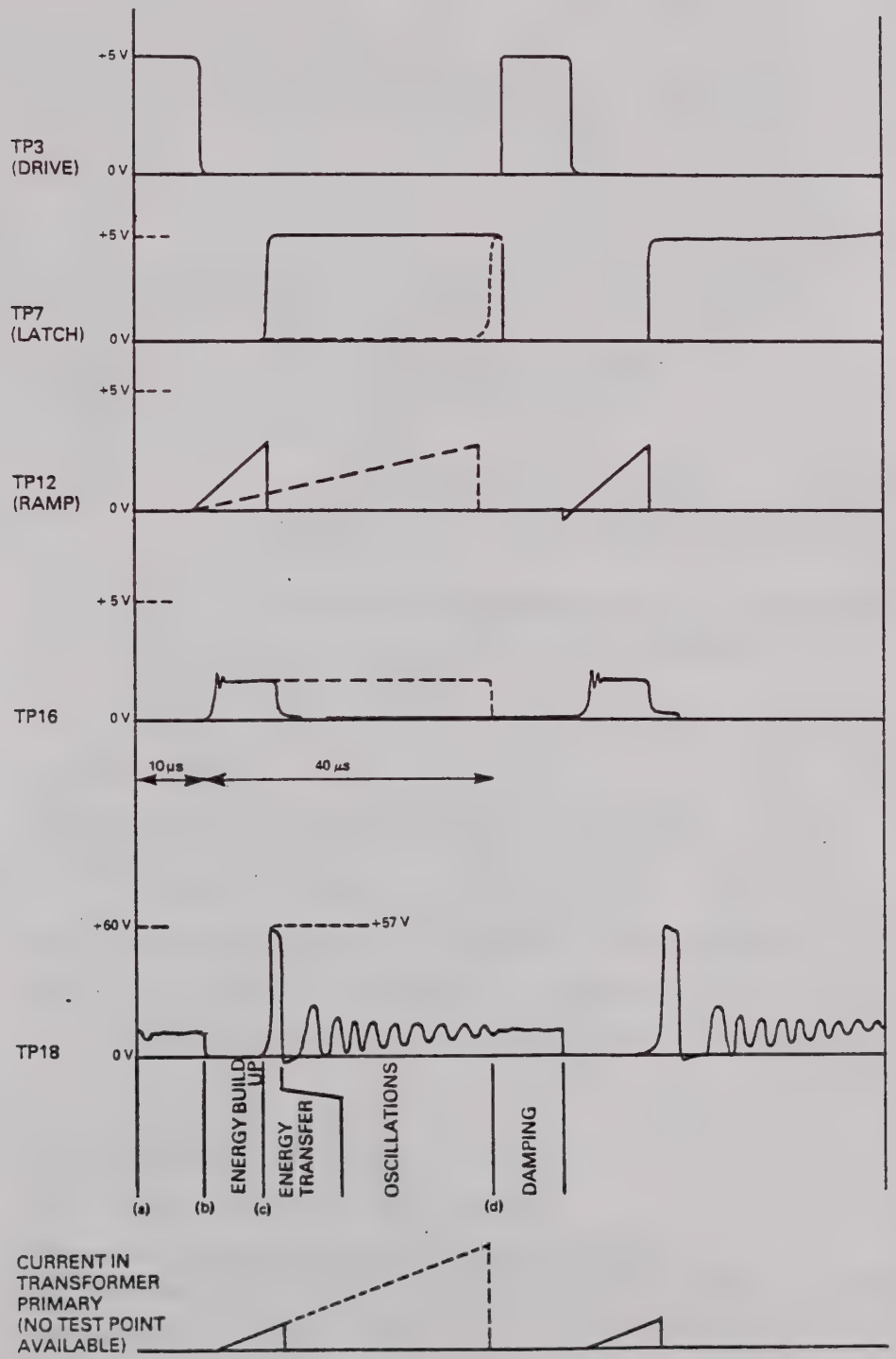
   Check waveform at TP18 looks like this typically good waveform.



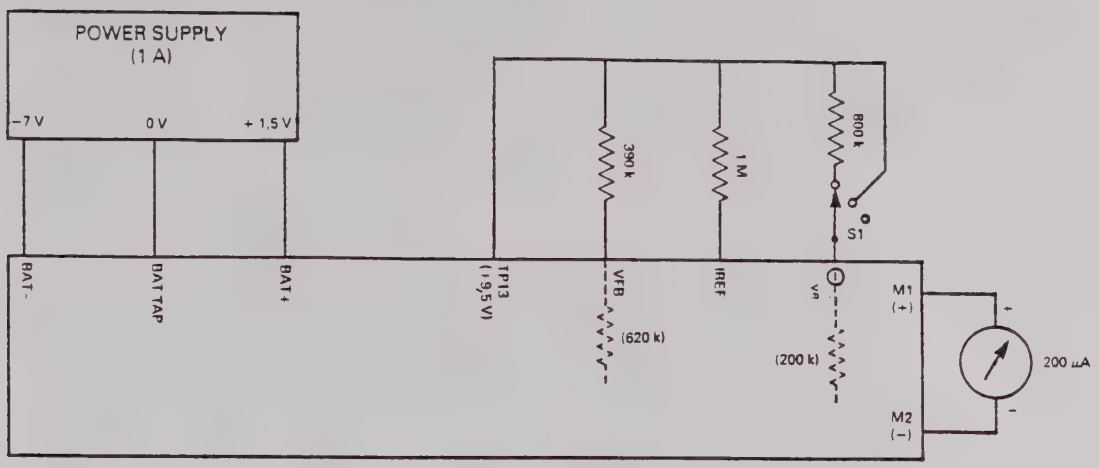
4.2 Typical waveforms for H.V. inverter

——— at 5 kV on light load

- - - - at 5 kV on heavy load



4.3 Instrumentation Board, (tested in isolation from the instrument).



Circuit to test instrumentation board

Work through these basic steps to test the board

1. Visual Check: switch action for 5 positions
   switch wiring
   griplets and soldered connections to flying leads
   Polarity of 5 electrolytic capacitors C2, C7, C8, C17, C18
   Polarity of 19 diodes D1 to D4, D7, D9, D10, D12 D13, D16, D17, D30 to D35, D36, D37
   Polarity of D22a, D21, D22.

2. Initial set-up
   Set rotary switch fully clockwise (5 kV position)
   Set pots: H(R62), F(R113), D(R119) to mid position
   B(80), G(R64) fully anti-clockwise
   Apply clip to micro-switch to hold it in the on position.

   Note:- all voltage measurements are made with respect to TP20 or BAT.GND.
   start with test circuit switch S1 set on 800 kΩ

3. Check current consumption
   (a) <60 mA for -7 V supply
   (b) 60 mA - 120 mA for +1,5 V supply

   if not there may be an L.V. inverter problem.
   for (a) lack of -ve rail will cause excessive current to be drained by the positive rail. Check loading: Voltage across R37 and R38 should be ≙220 mV.

or for (b) TR14/R35 should drain 50 mA.
In addition to this TR21 should be turned off (TP17 = +6 V) so that BAT+ supply is supplying approx. 40 mA to run the L.V. inverter.
Possible causes of excessive current: D17 or TR21 reversed.

4. Check TP13 +9,5 V ± 10%
TP14 -9,5 V ± 10%
if not there may be an L.V.inverter problem. Check TP10 waveform.
If voltage is low check voltage across R37 and R38.
If greater than 300 mV current drain is excessive.
Typical causes: TR35 s/c
IC3/IC5 either faulty or o/c input pins.

5. Adjust potentiometer A (R73) so that TP19 = 0 V ± 1 mV
TP22 should be approx. -0,3 V, if not:
Check IC3 V+ and V- supplies (pins 7 and 4).
Check LK2.
Check feedback loop via R79 and TR27.

6. Select on test resistors R90/R91 should give TP25 = 0 V ± 30 mV.
The test jig pushes equal currents through TR27 and TR28.
TP24 should be 0 V ± 2 mV.
If not check D22a (if in doubt remove D22a).
A small amount of noise always exists on TP25 (≙5 mV the 1 Hz oscillator). Excessive noise usually points to a fault in R64/ TR26/IC4.

7. Adjust potentiometer E (R31) to give meter reading at centre scale (100 MΩ) Check TP29 = 6,4 V ± 5%. TP30≙2,5 V.
If these are correct measure 50 mV between TP27 and TP28.
If this is not 50 mV there is current leaking in sideways to the meter movement. Suspect TR32 (has the base been connected to something inadvertently?), TR33 or TR34. Or pots D or F not set in mid position.

8. Set S1 on the test jig to the short circuit position. Adjust potentiometer C (R96) so that meter reads 20 MΩ.
If meter will not move above half scale first suspect is D22a reverse polarity.

Open circuit the - terminal to verify gain of IC5 circuit:
Meter should read ∞ , TP25 = +3,2 V, TP24 = +0,15 V.

9. Set S1 on the test jig to the open circuit position. Adjust potentiometer H (R61) so that the meter reads ∞
(note: set pot. H back to the mid position afterwards)
Work back through test points:

TP30 = +3,2 V
TP25 = +3,2 V
TP24 = +0,15 V
TP22 ≙ -0,25 V

The infinity position relies on current entering the amplifier via R62. If this current is absent the pointer will go off scale and TP22 will rise to 0 V or even go to a positive level.

10. Reduce 1,5 V supply to 0 V and observe small oscillations on meter (± 1 mm) approx.
TR16 should detect low voltage of B1
TP17 should be ≺1,2 V
D31 becomes reverse biassed allowing the oscillations on IC4 pin 3 to be applied to IC5 input.

11. Reduce 7 V supply to 5,6 V.
Set potentiometer G (R64) for large pointer oscillations.
Back off pot. G slowly so that large oscillations just stop.
Remove clip from switch.
If there is a problem check R64, TR26 or IC4.

12. Charging circuit check
Connect a 39 Ω 1 W resistor between BAT+ and BAT-.
Apply a.c. volts (d.c. will do if no a.c.available) between AC1 and AC2.
Vary the voltage from 10 V to 27 V.
Measure voltage across 39 Ω resistor to be 8 V ± 2 V.
R17 (3,3 Ω) monitors the 200 mA charging current.
TR7 is the series current regulator transistor.
R15 conducts when high voltages are applied thus aiding TR7 in power dissipation.

4.4 Additional Tests,(on the complete instrument).

1. Check reading on all voltage settings.

If greatest error occurs between 2,5 kV and 5 kV this is probably caused by R94 having a poor voltage coefficient.
If greatest error occurs between 500 V and 1 kV this is probably caused by either:
(a) Leakage into IC5 input (measure this across R83) or
(b) TR28 having a poor charateristic at low levels.

2. If the potentiometer H (R61) will not provide sufficient adjustment the problem is either a severe non-linearity in the meter movement or an electronic fault.
The wiper of pot.H should be at 6,15 V at mid position, giving a current through R62 of 123 mA. (These figures are for 5 kV setting - proportionally lower figures apply at lower voltages).

3. Infinity shift at low voltage usually indicates leakage by some component connected to TP19.
To check for leakage of D21, D22, C27 and TR27 turn potentiometer A (R73) from one end to the other. If these four components are satisfactory the pointer will return to its original position after a few seconds. Return the pot. to its original position after doing this test.

4.5 Instrumentation Trouble-shooting

Ground reference: Use TP20 for optimum accuracy.
Alternatively use the guard terminal.

Use a voltmeter with an impedance of at least 100 kΩ.
Set voltage switch to 500 V.

The following table will locate catastrophic faults quickly.
Faults which cause errors of less than 5% of scale length might not be located as easily and may necessitate referring to the calibration procedure.

Test Point	Terminal Open-Circuit	+ & - Terminals Short-Circuit
TP13	+ 9,5 V ± 10%	Same as open circuit
TP14	- 9,5 V ± 10%	" " " "
TP29	+ 6,4 V ± 5%	" " " "
TP19	0,0 V ± 10 mV	" " " "
- Terminal	———	+ 200 V ± 20%
TP22	- 0,35 V ± 0,05 V	-5 V ± 1 V
TP23	- 0,35 V ± 0,05 V	- 0,6 V ± 0,1 V
TP24	+ 0,15 V ± 10%	- 0,15V ± 10%
TP25	+ 3,2 V ± 5%	- 3,2 V ± 5%
TP30	+ 3,2 V ± 5%	+ 2,2 V ± 5%
TP28 w.r.t.TP27	0 V ± 1 mV	100 mV ± 5%
TP26	0 V ± 0,1 V	0 V ± 0,1 V

If the only faulty reading is between test points TP28 and TP27 remove the following components until the fault disappears:

TR31 (or cut the link in its collector track)

R115 (check TR32 base is open circuit first)

TR33

TR34

D33

4.6 Excessive Drift Due to Temperature

Note: At extreme temperatures (i.e. -15 ^{o}C or +55 ^{o}C) the infinity and zero position might shift by up to 1,7 mm. Such changes are quite normal. Changes of more than this, or changes of more than 0,04% of f.s.d. per ^{o}C justify investigation.

If drift occurs when measuring a 100 MΩ resistor:

Connect TP24 to TP20 (this connects IC5 input to ground). The meter should now read centre scale (which is 100 MΩ) ± 5% of full scale. Check drift as temperature is increased at TP25 (50 mV represents 1% f.s.d.) and TP30 (50 mV represents 1% f.s.d.)

Excessive drift observed at Test Point	Possible causes
TP30	1. Zener diode D38 poor temperature coeff. Check TP29 to confirm 2. Leaky TR34
TP25	1. IC5 has poor temperature coeff. or is leaky. 2. C41 is leaky - disconnect to confirm
If no excessive drift occurs.	Fault is before TP24 - disconnect shorting link. If drift is more pronounced on 500 V range than on the 5 kV range, components TR28 or IC5 may be leaky.

4.7 Summary of Test Point Voltages

TP1 3,1 V ± 0,1 V

TP2 0 V for maximum power demand

4 V for zero power demand

2 V typical at 5 kV on no load

TP3 $\overline{\text{DRIVE}}$ Master timing pulse (see waveform diagram)

TP4/TP5 Charging current check (200 mA)

TP6 5,3 V (assuming supply rail = 7 V) no output load.

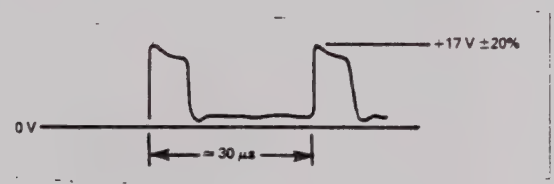
Note TP6-TP15 ≙ 0,7 V when current limit operates.

TP7 LATCH (see waveform diagram)

TP8 0,05 V TP6.

TP9 —

TP10



TP11 +7 V

TP12 RAMP (see waveform diagram)

TP13 +9,6 V ± 10%

TP14 -9,6 V ± 10%

TP15 5,3 V (assuming supply rail = 7 V)

TP16 (see waveform diagram)

TP17 > + 6 V normal. < 2 V for LOW BAT (B1 discharged)

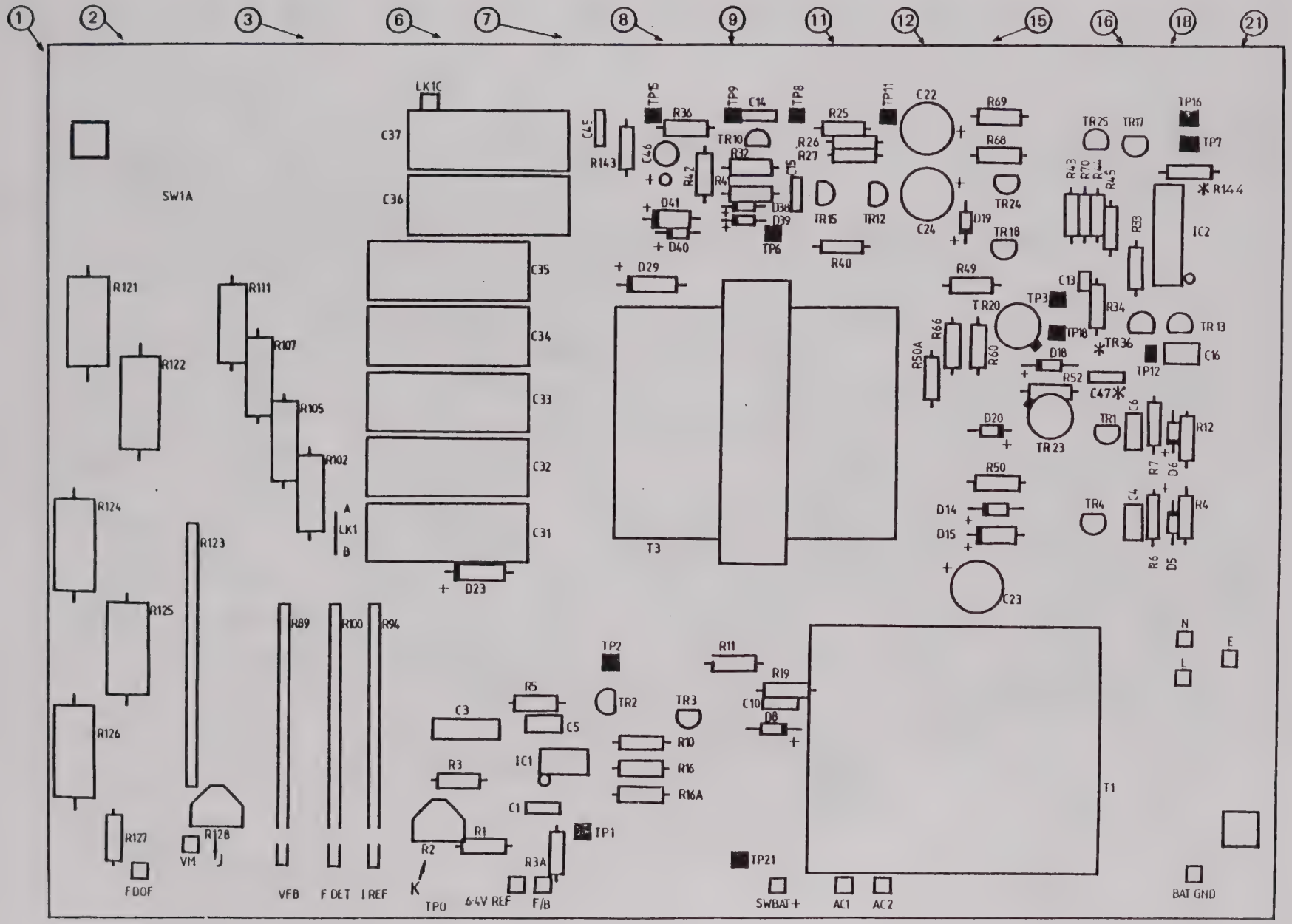
TP18 (see waveform diagram)

TP19 0 V ± 2 mV (measure with respect to TP20)

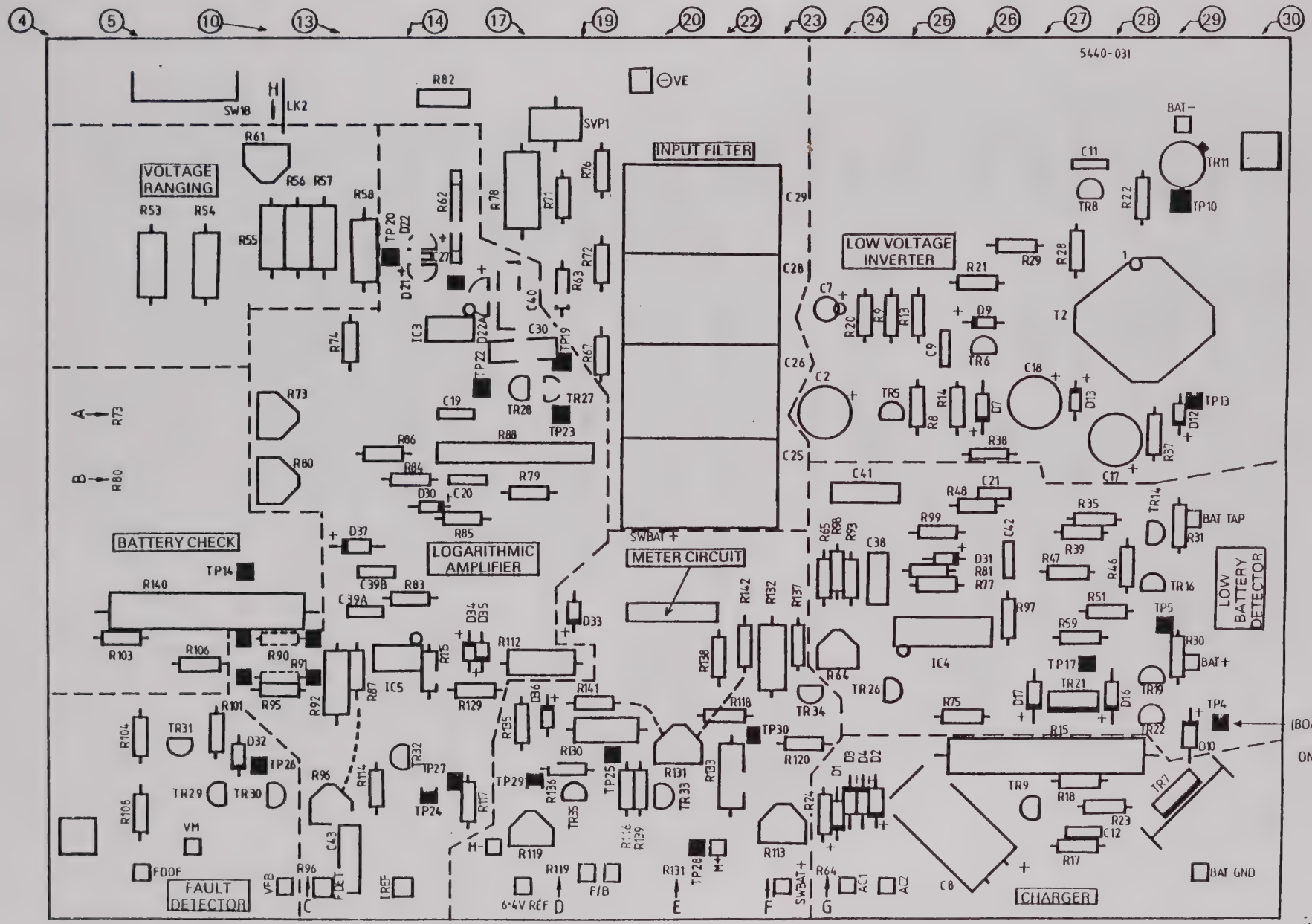
TP20 0 V Instrumentation ground reference (⏚)

TP21	0 V H.V. board ground reference (⏚)
TP22	-0,35 V ± 0,05 V at 500 V, terminals open circuit
TP23	-0,35 V ± 0,05 V " " " "
TP24	+0,15 V ± 10% " " " "
TP25	+3,2 V ± 15% " " " "
TP26	0 V (up to +3 V when fault detector operates)
TP28-TP27	200 mV ± 15% at 0 Ω (f.s.d.)
TP29	6,4 V ± 5%
TP30	3,2 V ± 15% at ∞ (TP30 = TP25 at ∞)

Note: TP20 is the most accurate ground reference but most measurements can be made with respect to either the guard terminal or the BAT GND wire (by TP4).



* Added in Spring 1985 on HV pcb issue 3



INSTRUMENTATION BOARD: TEST POINT LOCATION

5. SETTING UP PROCEDURE

5.1 Test Equipment Required

1. Dual power supply unit 0 - 10 V at 2 A fitted with current meters. (for - 7 V/-5,5 V +1,2 V/ 0 V supplies)
2. Resistance box with resistances 10 GΩ 1 GΩ 100 MΩ 10 MΩ 1 MΩ 0 Ω (Resistances must be able to withstand 5 kV)
3. Voltmeter 5 kV >100 MΩ impedance.
4. Meter to measure up to 10 V (10 MΩ impedance) e.g. DA116.
5. Voltage source accurate to 0,5% for 100 V 500 V 1000 V d.c. voltage source accurate to 1% for 500 V a.c. (50 Hz)
6. 50 Hz supply for 250 V and/or 110 V a.c.
7. Capacitor 0,1 µF (>2,5 kV d.c. rating) in series with 1 MΩ.

5.2 Test Procedure

1. Check that the battery fuses are <u>not</u> fitted.
2. Connect power supply to BAT-, BATTAP and BAT+.
3. Switch to battery check position, press button, read 6,5 V to 8 V.
4. Connect 5 kV volmeter.
   Switch to 5 kV, press button and adjust pot K for 5 kV (± 1%).
   Check current consumption is less than 350 mA.
5. Check that other voltages (i.e. 2,5 kV 1 kV 500 V) are correct ± 3%.
6. Switch resistor box to 10 MΩ and check output voltage to be at least 4750 V on 5 kV range.
   Current consumption must not exceed 800 mA.
7. Connect 10 mA meter between + and - terminals. Switch to 5 kV, press button.
   Current must read 1 mA to 1,5 mA.
8. Set mechanical zero so that pointer rests in the centre of the ∞ line. (Tap the meter gently to ensure that it has settled).
9. Set pot. B fully anti-clockwise.
   Set pots. F, H to centre.
   (pot. A has been set up when the board was tested. If in doubt measure voltage at TP19 with respect to TP20. This should read 0 V ± 2 mV).

10. Make adjustments according to the following table.

	Range	Resistor	Adjust	Measure
a)	1 kV	100 MΩ	E	Set Scale to 100 MΩ
b)	5 kV	100 MΩ	Check	Scale = 100 MΩ ± 0,5 mm
c)	1 kV	10 GΩ	C	Set Scale to 10 GΩ
d)	2,5 kV	∞ (Remove Resistor Box)	H	Set Scale to ∞
e)	500 V	∞ (Remove Resistor Box)	Check	∞
f)	5 kV	∞ (Remove Resistor Box)	Check	∞
g)	500 V	1 MΩ	D	Set Scale to 1 MΩ
h)	5 kV	1 MΩ	B	Set Scale to 1 MΩ
i)	1 kV	0 Ω	F	Set Scale to 0
j)	5 kV	1 MΩ	Check	1 MΩ ± 1 mm
k)	5 kV	10 MΩ	Check	10 MΩ ± 1 mm
l)	5 kV	100 MΩ	Check	100 MΩ ± 1 mm
m)	5 kV	1 GΩ	Check	1 GΩ ± 1 mm
n)	5 kV	10 GΩ	Check	10 GΩ ± 1 mm
o)	5 kV	∞ (Remove Resistor Box)	Check	∞

Notes:

1. When setting '∞' the pointer should be set to the centre of the '∞' line.
2. When setting the '0' the pointer should be set to the right hand side of the '0' line.
3. When performing a check at '∞' the pointer must come to rest somewhere on the '∞' line.
   i.e. The '∞' line must be visible on either side of the pointer.

11. Reduce BAT+ to 0 V, press button and verify that small oscillations (approx. ± 1 mm) are superimposed on the reading.
12. Reduce BAT- to -5,5 V, press button and set pot. G for larger pointer oscillations. Back off pot. G slowly until oscillations just stop.
13. Switch off and disconnect power supply.
14. Switch to 5 kV and perform the following for voltage measurement calibration:
    (a) Apply 500 V d.c. between '+' and '-' terminals and adjust pot. J for correct reading (or within ± 4%).
    (b) Apply 1000 V d.c. Check reading to ± 4%.
    (c) Apply 100 V d.c. Check reading to ± 10%.

(d) Apply 500 V a.c. (50 Hz) Check reading to ± 10% of reading.
If checks (b), (c) or (d) fail pot. J may be re-adjusted.
The four conditions (a), (b), (c) and (d) must then be re-checked.

15. Switch to battery check position.
16. Fit fuses (Battery fuses 2 A, Mains fuses 100 mA anti-surge)
17. Connect 1 A meter between TP4 and TP5. Place the instrument in its case (but do not screw it up). Apply approx. 240 V a.c. to mains input, check that neon lights and current reads 200 mA ± 20%. Apply approx. 110 V a.c. and check current: 200 mA ± 20%. Switch off mains supply before removing test clips. (Optional: The battery may be allowed to charge for about one minute. Pressing the 'TEST' button briefly about once every fifteen seconds will indicate whether the battery is actually charging).
18. Screw the instrument into its case.
19. Switch to ⊣|⊢, press button and hold down for at least 5 seconds. Observe that pointer stays in the 'good battery' position. If not, give the battery an overnight charge.
20. Still in ⊣|⊢ position, press button and connect 110 V ~ to mains input. Observe battery voltage to increase by approx 0,1 V as supply is connected. Replace charger cover.
21. Check balance in vertical plane at 45° either way ∞ 1,5 mm max.
22. Switch to 2,5 kV.
    Connect to test capacitor (0,1 µF in series with 1 MΩ), press 'TEST' button. Observe steady reading - dither not to exceed 3 mm pk-pk.
    Release button slowly and observe.
    (a) Approx. ½ scale deflection (between 200 V and 800 V)
    (b) Rapid decay to zero.

5.3 Summary of Functions of Potentiometers

Pot A (R73)	Input offset volts
Pot B (R80)	Emitter resistance compensation
Pot C (R96)	Gain
Pot D (R119)	Upper scale linearity
Pot E (R131)	Scale off set
Pot F (R113)	Extreme upper scale linearity
Pot G (R64)	Dead battery detector
Pot H (R61)	Set infinity (Extreme lower scale linearity)
Pot J (R128)	Voltmeter adjust
Pot K (R2)	Test voltage adjust

6.1 High Voltage P.C.B.

R1	Resistor	270 kΩ ± 5%	1/3 W
R2	Potentiometer	100 kΩ ± 20%	
R3	Resistor	270 kΩ ± 5%	1/3 W
R3a	Resistor	470 kΩ ± 5%	1/3 W
R4	Resistor	4,7 kΩ ± 5%	1/3 W
R5	Resistor	150 kΩ ± 5%	1/3 W
R6	Resistor	27 kΩ ± 5%	1/3 W
R7	Resistor	100 kΩ ± 5%	1/3 W
R10	Resistor	1,5 kΩ ± 5%	1/3 W
R11	Resistor	3,9 kΩ ± 5%	1/3 W
R12	Resistor	1,8 kΩ ± 5%	1/3 W
R16	Resistor	680 Ω ± 5%	1/3 W
R16a	Resistor	470 kΩ ± 5%	1/3 W
*R19	Resistor	330 Ω ± 5%	1/3 W (180 Ω from Spring 1985 - board issue 3)
R25	Resistor	680 Ω ± 5%	1/3 W
R26	Resistor	22 Ω ± 5%	1/3 W
R27	Resistor	2,2 kΩ ± 5%	1/3 W
R32	Resistor	1 kΩ ± 5%	1/3 W
R33	Resistor	47 kΩ ± 5%	1/3 W
R34	Resistor	47 kΩ ± 5%	1/3 W
R36	Resistor	4,7 kΩ ± 5%	1/3 W
R40	Resistor	680 Ω ± 5%	1/3 W
R41	Resistor	4,7 kΩ ± 5%	1/3 W
R42	Resistor	2,2 kΩ ± 5%	1/3 W
R43	Resistor	27 kΩ ± 5%	1/3 W
R44	Resistor	27 kΩ ± 5%	1/3 W
R45	Resistor	27 kΩ ± 5%	1/3 W
R49	Resistor	1,5 kΩ ± 5%	1/3 W
R50	Resistor	10 Ω ± 5%	1/3 W
R50a	Resistor	3,3 kΩ ± 5%	1/3 W
R53	Resistor	100 Ω ± 5%	1/3 W
R60	Resistor	10 Ω ± 5%	1/3 W
R66	Resistor	39 Ω ± 5%	1/3 W
R68	Resistor	1 kΩ ± 5%	1/3 W
R69	Resistor	1 kΩ ± 5%	1/3 W
R70	Resistor	27 kΩ ± 5%	1/3 W
R89	Resistor	100 MΩ ± 2%	(5kV max., voltage coeff. 3ppm/V)
R94	Resistor	100 MΩ ± 2%	(5kV max., voltage coeff. 3ppm/V)
R100	Resistor	200 MΩ ± 5%	(5kV)
R102	Resistor	82 kΩ ± 5%	1 W
R105	Resistor	82 kΩ ± 5%	1 W
R107	Resistor	82 kΩ ± 5%	1 W
R111	Resistor	47 kΩ ± 5%	1 W
R121	Resistor	39 kΩ ± 5%	2 W
R122	Resistor	39 kΩ ± 5%	2 W
R123	Resistor	1,8 MΩ ± 5%	(5 kV)
R124	Resistor	39 kΩ ± 5%	2 W
R125	Resistor	39 kΩ ± 5%	2 W
R126	Resistor	39 kΩ ± 5%	2 W
R127	Resistor	4,7 kΩ ± 5%	1/3 W
R128	Potentiometer	1 MΩ ± 20%	
R143	Resistor	100 kΩ ± 5%	1/3 W
*R144	Resistor	1 kΩ ± 5%	½ W
C1	Capacitor	0,01 µF ± 10%	63V
C3	Capacitor	0,1 µF ± 10%	100 V
C4	Capacitor	470 pF ± 5%	100 V
C5	Capacitor	470 pF ± 5%	100 V
C6	Capacitor	470 pF ± 5%	100 V
C10	Capacitor	0,1 µF ± 10%	63 V
C13	Capacitor	47 pF ± 2%	63 V
C14	Capacitor	0,1 µF ± 10%	63 V
C15	Capacitor	0,1 µF ± 10%	63 V
C16	Capacitor	470 pF ± 5%	100 V
C22	Capacitor	100 µF	16 V electrolytic
C23	Capacitor	100 µF	16 V electrolytic
C24	Capacitor	100 µF	16 V electrolytic
C31	Capacitor	0,047 µF	(1,5 kV)
C32	Capacitor	0,047 µF	(1,5 kV)
C33	Capacitor	0,047 µF	(1,5 kV)
C34	Capacitor	0,047 µF	(1,5 kV)

C37	Capacitor	0,047 µF (1,5 kV)
C45	Capacitor	0,1 µF ± 10% 63 V
C46	Capacitor	2,2 µF 35 V electrolytic
* C47	Capacitor	0,01 µF ± 10% 63V

D5	Diode	1N4148
D6	Diode	1N4148
D8	Zener diode	BZY88 C5V1
D14	Zener diode	1N4162B
D15	Diode	1N4002
D18	Zener diode	BZX79C68
D19	Diode	1N4148
D20	Diode	1N4148
D23 to D29	Diode	SL500
D38 to D40	Diode	1N4148
D41	Zener diode	BZY88C9V1

TR1	Transistor	BC183
TR2	Transistor	BC183
TR3	Transistor	BC213
TR4	Transistor	BC183
TR10	Transistor	BC213
TR12	Transistor	BC213
TR13	Transistor	BC183
TR15	Transistor	BC213
TR17	Transistor	BC183
TR18	Transistor	BC183
TR20	Transistor	2N3053
TR23	Transistor	BDX36
TR24	Transistor	BC213
TR25	Transistor	BC183

IC1	Integrated circuit	CA3140
* IC2	Integrated circuit	IC4001 (74LS 02 from spring 1985 - board issue 3)

T1	Transformer	240V :12V 12VA

6.2 Instrumentation

R8	Resistor	5,6 kΩ ± 5%	⅓ W
R9	Resistor	47 kΩ ± 5%	⅓ W
R13	Resistor	560 Ω ± 5%	⅓ W
R14	Resistor	180 kΩ ± 5%	⅓ W
R15	Resistor	220 Ω ± 10%	7 W
R17	Resistor	3,3 Ω ± 5%	⅓ W
R18	Resistor	100 Ω ± 5%	⅓ W
R20	Resistor	8,2 kΩ ± 5%	⅓ W
R21	Resistor	8,2 kΩ ± 5%	⅓ W
R22	Resistor	100 Ω ± 5%	⅓ W
R23	Resistor	1 kΩ ± 5%	⅓ W
R24	Resistor	1 kΩ ± 5%	⅓ W
R28	Resistor	47 Ω ± 5%	⅓ W
R29	Resistor	4,7 kΩ ± 5%	⅓ W
R30	Resistor	1 kΩ ± 5%	⅓ W
R31	Resistor	2,7 kΩ ± 5%	⅓ W
R35	Resistor	22 Ω ± 5%	⅓ W
R37	Resistor	22 Ω ± 5%	⅓ W
R38	Resistor	22 Ω ± 5%	⅓ W
R39	Resistor	1,2 kΩ ± 5%	⅓ W
R46	Resistor	100 kΩ ± 5%	⅓ W
R47	Resistor	15 kΩ ± 5%	⅓ W
R48	Resistor	100 kΩ ± 5%	⅓ W
R51	Resistor	220 kΩ ± 5%	⅓ W
R53	Resistor	310 kΩ ± 1%	¼ W
R54	Resistor	160 kΩ ± 1%	¼ W
R55	Resistor	27 kΩ ± 1%	¼ W
R56	Resistor	27 kΩ ± 1%	¼ W
R57	Resistor	36 kΩ ± 1%	¼ W
R58	Resistor	62 kΩ ± 1%	¼ W
R59	Resistor	47 Ω ± 5%	⅓ W
R61	Potentiometer	1 MΩ ± 20%	
R62	Resistor	50 MΩ ± 5%	½ W
R63	Resistor	56 kΩ ± 5%	⅓ W
R64	Potentiometer	10 kΩ ± 20%	
R65	Resistor	56 kΩ ± 5%	⅓ W
R67	Resistor	33 kΩ ± 2%	⅓ W
R71	Resistor	3,9 MΩ ± 5%	⅓ W
R72	Resistor	33 kΩ ± 2%	⅓ W

R73	Potentiometer	10 kΩ ± 20%	
R74	Resistor	3,3 kΩ ± 5%	1/3 W
R75	Resistor	10 kΩ ± 5%	1/3 W
R76	Resistor	33 kΩ ± 2%	1/3 W
R77	Resistor	1 MΩ ± 5%	1/3 W
R78	Resistor	47 kΩ ± 5%	1 W
R79	Resistor	3,9 kΩ ± 5%	1/3 W
R80	Potentiometer	100 kΩ ± 20%	
R81	Resistor	1 MΩ ± 5%	1/3 W
R82	Thermister	1 kΩ cold	
R83	Resistor	100 kΩ ± 5%	1/3 W
R84	Resistor	100 kΩ ± 5%	1/3 W
R85	Resistor	1 MΩ ± 5%	1/3 W
R86	Resistor	100 kΩ ± 5%	1/3 W
R87	Resistor	12 kΩ ± 5%	1/3 W
R88	Platinum Resistor (100 Ω at 0°C)		
R90	Select on test		
R91	Select on test		
R92	Resistor	2,2 kΩ ± 1%	1/4 W
R93	Resistor	1 MΩ ± 5%	1/3 W
R95	Resistor	27 kΩ ± 5%	1/3 W
R96	Potentiometer	500 Ω ± 20%	
R97	Resistor	220 kΩ ± 5%	1/3 W
R98	Resistor	10 MΩ ± 5%	1/3 W
R99	Resistor	10 MΩ ± 5%	1/3 W
R101	Resistor	3,3 MΩ ± 5%	1/3 W
R103	Resistor	3,3 kΩ ± 5%	1/3 W
R104	Resistor	220 kΩ ± 5%	1/3 W
R106	Resistor	27 kΩ ± 5%	1/3 W
R108	Resistor	100 kΩ ± 5%	1/3 W
R112	Resistor	14 kΩ ± 1%	1/4 W
R113	Potentiometer	100 kΩ ± 20%	
R114	Resistor	390 kΩ ± 5%	1/3 W
R115	Resistor	6,8 kΩ ± 5%	1/3 W
R116	Resistor	100 kΩ ± 5%	1/3 W
R117	Resistor	390 Ω ± 2%	1/3 W
R118	Resistor	27 kΩ ± 5%	1/3 W
R119	Potentiometer	100 kΩ ± 20%	
R120	Resistor	220 kΩ ± 5%	1/3 W
R129	Resistor	2,2 kΩ ± 5%	1/3 W
R130	Resistor	3,9 kΩ ± 1%	1/4 W
R131	Potentiometer	1 kΩ ± 20%	
R132	Resistor	3,9 kΩ ± 1%	1/4 W
R133	Resistor	14 kΩ ± 1%	1/4 W
R135	Resistor	10 kΩ ± 5%	1/3 W
R136	Resistor	10 MΩ ± 5%	1/3 W
R137	Resistor	220 kΩ ± 5%	1/3 W
R138	Resistor	1 MΩ ± 5%	1/3 W
R139	Resistor	13 kΩ ± 2%	1/3 W
R140	Resistor	6,8 Ω ± 10%	7 W
R141	Resistor	47 kΩ ± 5%	1/3 W
R142	Resistor	47 kΩ ± 5%	1/3 W

C2	Capacitor	100 µF	16 V electrolytic
C7	Capacitor	10 µF	16 V electrolytic
C8	Capacitor	470 µF	40 V electrolytic
C9	Capacitor	0,1 µF ± 10%	63 V
C11	Capacitor	0,01 µF ± 10%	63 v
C12	Capacitor	0,01 µF ± 10%	63 V
C17	Capacitor	100 µF	16 V electrolytic
C18	Capacitor	100 µF	16 V electrolytic
C19	Capacitor	0,1 µF ± 10%	63 V
C20	Capacitor	0,1 µF ± 10%	63 V
C21	Capacitor	0,1 µF ± 10%	63 V
C25	Capacitor	1 µF ± 20%	400 V
C26	Capacitor	1 µF ± 20%	400 V
C27	Capacitor	47 pF ± 2%	63 V
C28	Capacitor	1 µF ± 20%	400 V
C29	Capacitor	1 µF ± 20%	400 V
C30	Capacitor	0,1 µF ± 10%	100 V
C38	Capacitor	0,47 µF ± 10%	10 V
C39a	Capacitor	0,01 µF ± 10%	63 V
C39b	Capacitor	0,01 µF ± 10%	63 V
C40	Capacitor	0,1 µF ± 10%	100 V

C41	Capacitor	0,1 μF ± 10%	100 V
C42	Capacitor	0,01 μF ± 10%	63 V
C43	Capacitor	0,01 μF ± 10%	630 V d.c. 300 V a.c.

D1 to D4	Diode	1N4002
D7	Zener diode	BZY88C9V1
D9	Diode	1N4148
D10	Diode	1N4002
D12	Diode	1N4148
D13	Diode	1N4148
D16	Diode	1N4002
D17	Diode	1N4002
D21	Diode	BC183
D22	Diode	BC183
D22a	Diode	BC183
D30 to D35	Diode	1N4148
D36	Zener diode	6,4 V 1N4565
D37	Diode	1N4002

TR5	Transistor	BC213	
TR6	Transistor	BC183	
TR7	Transistor	FT2955	
TR8	Transistor	BC183	
TR9	Transistor	BC213	
TR11	Transistor	2N3053	
TR14	Transistor	BC213	
TR16	Transistor	BC213	
TR19	Transistor	BC183	
TR21	Transistor	FT2955	
TR22	Transistor	BC183	
TR26	Transistor	BC213	
TR27	Transistor	BC183	Matched to 2 mV
TR28	Transistor	BC183	
TR29	Transistor	BC213	
TR30-TR34	Transistor	BC183	
TR35	FET	J113	

IC3	Integrated circuit	CA3140
IC4	Integrated circuit	IC4001
IC5	Integrated circuit	CA3140

SVP1	Surge voltage protector	part no. 28863-285
T2	Low voltage transformer	part no. 6231-067
SW1B	Micro switch	part no. 25475-581
S2	Rotary switch	part no. 25462-887

*These changes became effective in Spring 1985 and will be found on h.v. p.c.b. issue 3.

6.3 Recommended Spares List

	Part No
Movement assembly	6331-250
Outer window	5140-572
Inner window	5140-562
Window gasket	5140-563
Terminal assembly	6130-223
Terminal bush	5110-061
Terminal disc	5140-301
Charger cover assembly	6231-070
Range knob	23763-022
Range knob cap	23763-023
Case assembly (bottom)	6430-263
Lid assembly (top)	6430-129
Front panel gasket	5340-257
Charger cover gasket	5140-571
Flat foot	5110-340
Domed foot	22316-841
Battery charger lead	25424-860
3 m H.V. test lead (3 used)	6331-248
8 m H.V. test lead (3 used)	6331-249

1015-40 9001

7. INSTRUMENT REPAIRS AND SPARE PARTS

The manufacturer's service and spare parts organisation for MEGGER instruments:

THORN EMI Instruments Limited
Parts and Service Centre
Archcliffe Road
Dover
Kent CT17 9EN
England
Tel:Dover(0304)202620
Telex:96283 Avomeg G

Approved Repair Companies

A number of independent instrument companies in the U.K. have been approved for repair work on most MEGGER instruments, using genuine MEGGER spare parts. Their names and addresses are listed in the Warranty Booklet supplied with each new instrument.

Overseas

Instrument owners outside Great Britain should consult the Appointed Distributor/Agent for their country regarding spare parts and repair facilities. The Distributor/Agent will advise on the best course of action to take. Names and addresses of Overseas Distributors/Agents are given in the Warranty Booklet supplied with each new instrument.

If returning an instrument to Britain for repair, it should be sent, freight pre-paid, to the Parts and Service Centre at the address shown above. A copy of the Invoice and of the Packing Note should be sent simultaneously by airmail to expedite clearance through the U.K. Customs.

A repair estimate showing return freight and other charges will be submitted to the sender, if required, before work on the instrument commences.

NEW MEGGER INSTRUMENTS ARE GUARANTEED FOR 12 MONTHS FROM THE DATE OF PURCHASE BY THE USER.

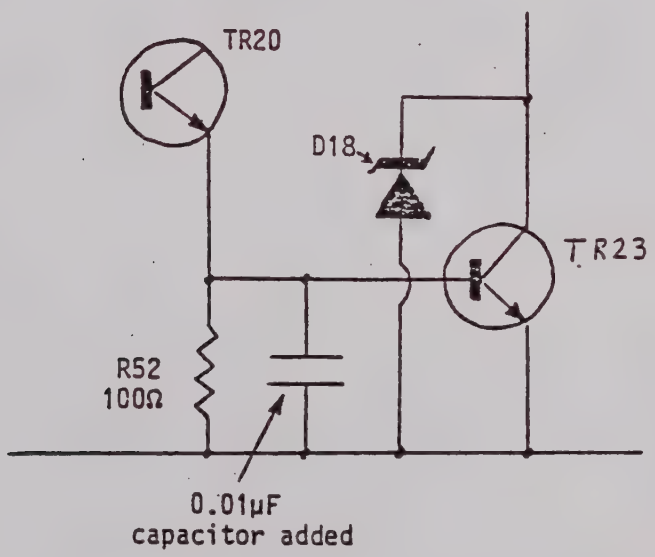
DESIGN MODIFICATION

To prevent the destruction of TR23 if a fault occurs in the control circuit, the following modification is suggested:

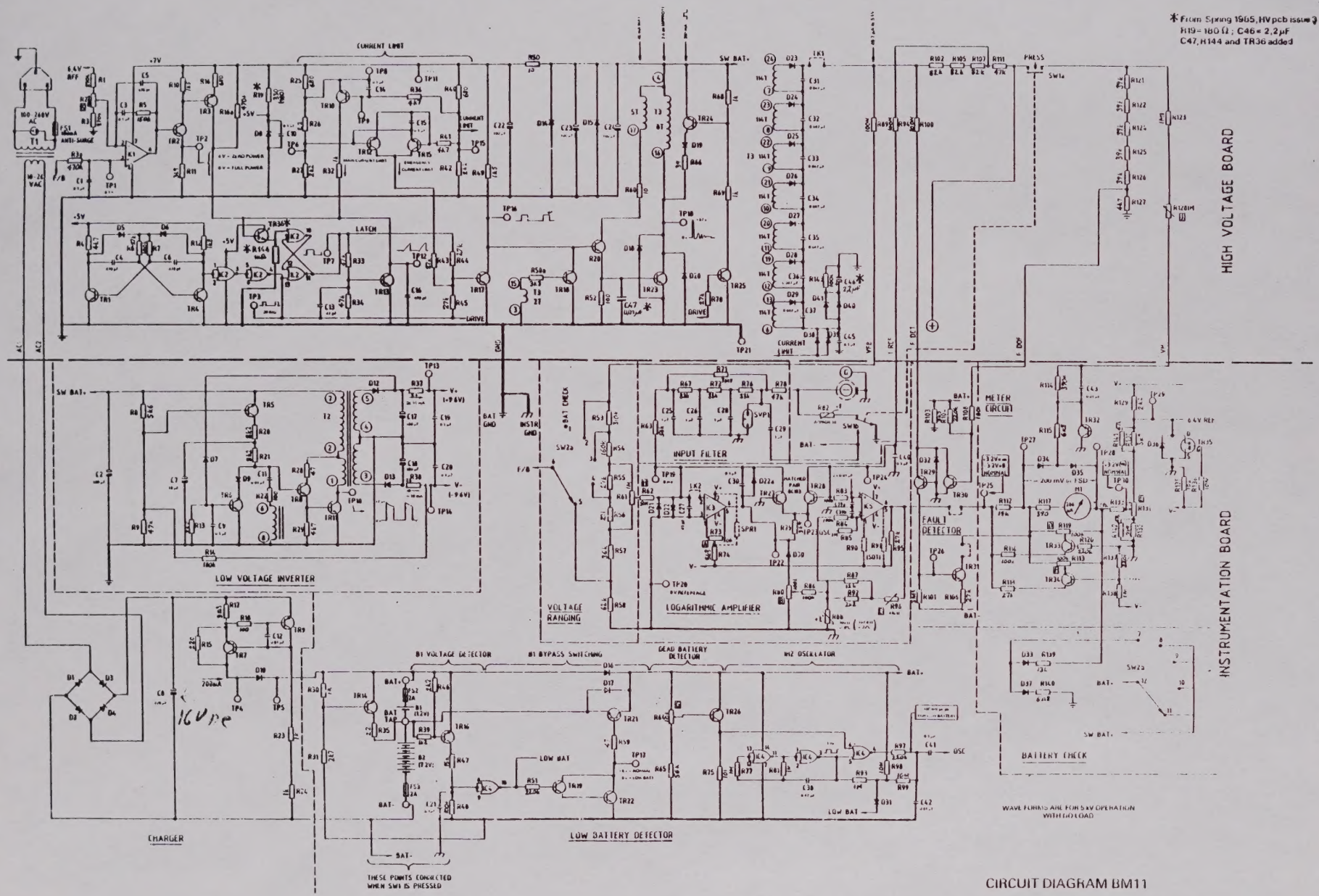
1. Remove D20. (The instrument will work adequately without this component).
2. Connect a 0,01 µF capacitor between the base of TR23 and ground (using the spare base hole by TR23 and the ground hole which was used by the negative end of D20).

Further protection can be gained by replacing D18 with a 68 volt zener diode with a 1,3 watt rating.

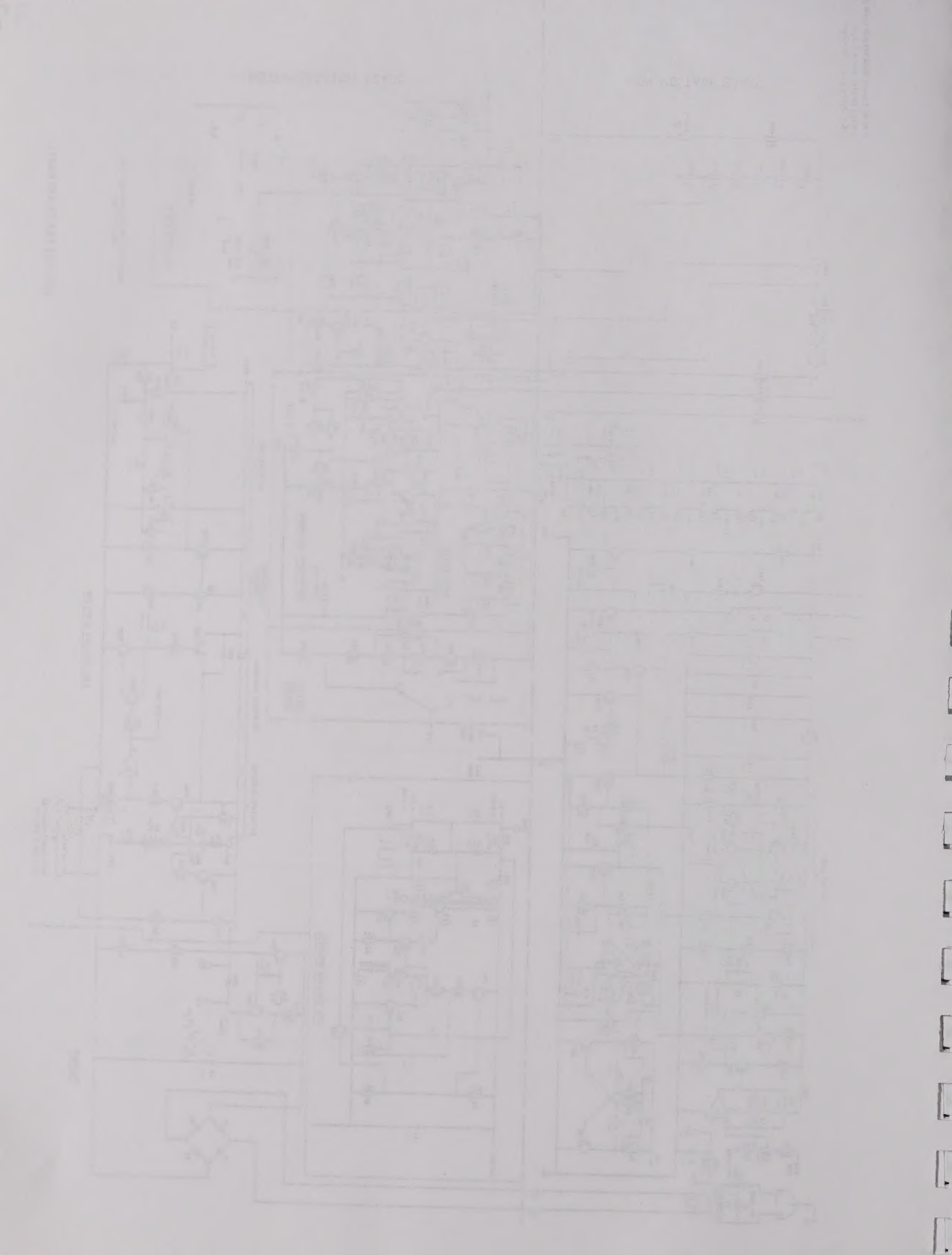
Modified circuit is as shown below:



Note:- This modification is required only on instruments with h.v. p.c.b's at issue 1 and 2. Design changes effective from Spring 1985 on h.v. p.c.b. issue 3 will eliviate the problem.



CIRCUIT DIAGRAM BM11



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